Bayesian statistical analysis using BUGS (WinBUGS, OpenBUGS, JAGS)

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What are WinBUGS, OpenBUGS and JAGS ?

- Software that does MCMC and use the BUGS language for model definition
- BUGS language is an ingeniously simple, yet very flexible and powerful language for defining even (very) complex statistical models
- Ideal for hierarchical models
- Programs do four things for you:
  - BUGS language lets you describe almost any statistical model as a simple HM
  - Translate BUGS model description into an MCMC algorithm
  - Run algorithm for as many steps as you wish and accumulate MCMC samples from joint posterior distribution of all unknown quantities in model
  - Do some processing of results, convergence monitoring, graphical/tabular summaries

What are WinBUGS, OpenBUGS and JAGS ? ctd.

- BUGS born 1989 in Cambridge/UK, later became WinBUGS; see Lunn et al. (2009), Statistics in Medicine, 28: 3049–3067.
- WinBUGS and OpenBUGS exist as standalone application (JAGS ?)
- All three usually best run from program R: use interface packages, e.g., R2WinBUGS, R2jags, rjags, R2OpenBUGS, BRugs
- WinBUGS not open-source, OpenBUGS open-source but some funny language, JAGS open-source and written in C++
- Development of WinBUGS stopped about 10 years ago. Developmental branch moved to OpenBUGS. However, development of OpenBUGS so far not much beyond WinBUGS
- JAGS separate project; developed by Martyn Plummer in Lyon/France.
- Definitions: "BUGS" == WinBUGS/OpenBUGS/JAGS, but sometimes only WinBUGS/OpenBUGS (distinguish from context)

The BUGS language in a nutshell

- Resembles R very much, but not identical (e.g., no equal sign)
- "Nodes": usually parameters, generally unknown quantities, also observed data
- All models in BUGS can be represented as graphs (directed acyclic graphs, DAGs)
- Two relationships among nodes: deterministic ($\leftarrow$), stochastic($\sim$)
- Math/stat functions; see manuals
- Statistical distributions; see manuals
- Not vectorized: need loops to define each element in an array (e.g., vector)
- "Declarative language": order of statements does not matter (with few exceptions)

BUGS as a giant glmer function

- R functions lmer()/glmer() in package lme4 most widely used to fit mixed models in ecology
- Mixed models = hierarchical models
- BUGS can do everything that glmer does AND MUCH MORE !
- **Think of BUGS as a super-powerful glmer function**

Contents rest of this module

- Show how to run WinBUGS as a standalone application (brief)
- Show how to run WinBUGS and JAGS from R (longer)